Feeding habits of whitemouth croaker *Micropogonias furnieri* (Perciformes: Sciaenidae) in Caraguatatuba Bay, southeastern Brazil

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Abstract

This study examined the feeding habits of *Micropogonias furnieri* in Caraguatatuba Bay. Samples were collected monthly between May 2003 and October 2004 by trawling in two areas (southern and northern parts of the bay). The fish were measured and their stomach contents identified. The abundance was compared between areas and among months. *M. furnieri* was more abundant in the southern area and in the spring of 2003. The population was dominated by small immature individuals. This species had a varied diet, feeding on crustaceans, bivalve siphons, and polychaetes. The ingestion of bivalve siphons may be an opportunistic behavior, due to the presence of a large bank of the bivalve *Tivela mactroides* in the study area. The high proportion of unidentified organic matter in the stomach corroborates published reports that this species eats continuously and has rapid digestion. These results demonstrate that *M. furnieri* can be considered a carnivore, with a preference for benthic organisms.

Descriptors: Fish, Diet, São Paulo, Western Atlantic.

Resumo

O objetivo principal desse estudo foi elucidar os hábitos alimentares de *Micropogonias furnieri* da Enseada de Caraguatatuba. As amostras foram coletadas mensalmente entre maio de 2003 e outubro de 2004, com redes de arrasto em duas áreas. As amostras foram medidas e o conteúdo alimentar identificado. A abundância foi comparada entre áreas (sul e norte) e entre meses. *M. furnieri* foi mais abundante na área sul durante a primavera de 2003. Durante o período estudado, houve um predomínio de indivíduos imaturos. Essa espécie apresenta uma dieta variada, alimentando-se de crustáceos, sifões de bivalves e poliquetas. A ingestão dos sifões de bivalves pode ser um comportamento oportunista, devido à presença de um grande estoque de *Tivela mactroides* na região. A grande quantidade de material orgânica não identificada nos conteúdo estomacal corrobora o fato desses indivíduos se alimentarem continuamente, apresentando uma rápida digestão. Esses resultados demostram que *M. furnieri* é uma espécie carnívora, com preferência a organismos bentônicos.

Descritores: Peixe, Dieta, São Paulo, Atlântico Ocidental.

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INTRODUCTION

Information on the feeding habits of fish is useful to understand the basic functioning of fish assemblages, is widely used for autoecology studies and modeling, and is an increasingly important tool in ecologically based management (KULBICKI et al., 2005). Numerous studies have examined the feeding habits of many fish species worldwide (HYNES, 1950; HYSLOP, 1980; PIANKA, 1988; MOTTA et al., 1995; BERGMANN & MOTTA, 2005; BIZZARRO et al., 2007; MUÑOZ et al., 2011). These variations are related mainly to morphology, sex, age, individual size, locale, and season (PIANKA, 1988; WOOTTON, 1990; BOLNICK et al., 2003; MENDOZA-CARRANZA & VIEIRA, 2008).

The whitemouth croaker *Micropogonias furnieri* (DESMAREST, 1823) is widely distributed off the eastern coast of the Americas, from the Antilles to Argentina (CASATTI et al., 2003). This croaker is a demersal coastal species, abundant on sand, silt and gravel bottoms of estuaries, bays and along the coast, between 1 and 100 m deep (most commonly above 30 m), reaches 75 cm total length and 4.5 kg weight, and can live up to 40 years (FISCHER et al., 2004). Because of its abundance, the species is one of the most important and traditional targets of artisanal fisheries in estuaries of Brazil, Argentina, and Uruguay (CHAO, 2002; JANATA et al., 2005; BORGES et al., 2007). In 2004, there were 35,183 landings from marine fisheries, with a total production of over 27,700 tons of fish. *M. furnieri* was the second most abundant (13.2%), behind the true sardine *Sardinella brasiliensis* (26.9%) (ÁVILA-DA-SILVA et al., 2005).

Studies on the feeding habits of whitemouth croaker were carried out by VAZZOLER (1991), FIGUEIREDO & VIEIRA (1998), GONÇALVES & VIEIRA (1999), RUIZ et al. (2001), SOARES & VAZZOLER (2001), FRERET & ANDREATA (2003), FIGUEIREDO & VIEIRA (2005), GIBERTO et al. (2007), MENDOZA-CARRANZA & VIEIRA (2008) and MORASCHE et al. (2010). Generally, the feeding habit of *M. furnieri* is quite diverse, ranging from crustaceans (as *Kalliapseudes schübartii*), molluscs (as *Erodona mactroides*), polychaetes (as *Hemipodus* sp.), small fish, ophiuroids and, algae (as chlorophytes and diatoms) (CARVALHO-FILHO 1992, FISCHER et al., 2004, MENDOZA-CARRANZA & VIEIRA 2008). FIGUEIREDO & VIEIRA (2005) showed that the whitemouth croaker feeds more intensively during the day. Changes in water transparency seem to affect the diel feeding pattern and food consumption.

This study examined aspects of the feeding habits of *M. furnieri* in two areas of Caraguatatuba Bay over a period of 15 months. It was intended to contribute to knowledge of this economically and ecologically important fish in the coastal region, and also to knowledge of the Caraguatatuba Bay system.

MATERIAL AND METHODS

Study area

Caraguatatuba Bay (23º37'S to 23º44'S and 45º24'W to 45º26'W) has a total width of about 16 km. Two homogeneous areas of 2 x 2 km each were selected so as to minimize the influence of the Juqueriquerê, Lagoa and Santo Antônio rivers on the results. The southern area extends from Porto Novo to Palmeiras beaches and has a gentler slope. This area is more exposed to wave activity and is influenced to some degree by the Juqueriquerê River, which forms a small estuary. The northern area, extending from Indaiá to Centro beaches, has a steeper slope, is relatively sheltered from wave energy, and is little influenced by the two smaller rivers, Lagoa and Santo Antônio (Figure 1).

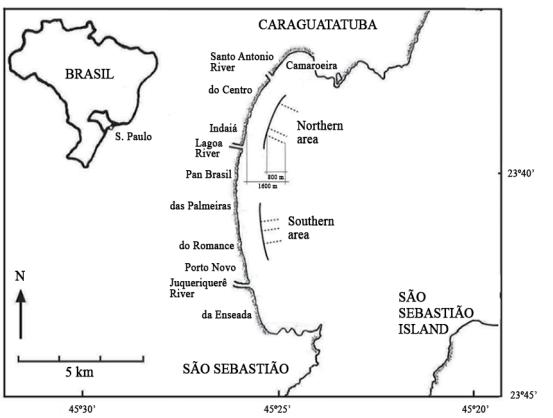

Figure 1. Caraguatatuba Bay and surroundings. The study areas (southern and northern) are represented by the gray squares.

Sampling method

Samples were taken monthly between July 2003 and October 2004. Three sampling stations were chosen in each area, among 200 possibilities, *i.e.*, the beach length of 2000 m divided into 10-m intervals. The position of the station was stored in a GPS at MLW (Mean low water) and then an 800-m distance was marked perpendicularly to the shore, from a fishing boat.

A 800-m trawl was performed at each station, at a speed of 1 knot, from 800 to 1600 m perpendicularly to the

shoreline at MLW. This interval is equivalent to a depth from 1 to 4 m. Trawls were performed using two otter trawls with a 2.0 cm mesh, mouth aperture of 1.6 m in height and 6.0 m in length, bag depth of 3.5 m.

Fish were removed from the net and immediately preserved in a 10% formalin solution in order to paralyze the enzyme action, preserving the digestive-tube contents (UIEDA & CASTRO 1999). The samples were identified and stored in plastic containers. After identification to species level, all specimens were transferred to 70% ethanol.

Population analysis and diet

All individuals of *M. furnieri* obtained in the samples were measured for standard length (SL), which is the distance between the anterior head edge and the caudal fin base edge (beginning of caudal fin rays; FIGUEIREDO & MENEZES, 1978). A total of 160 individuals of *M. furnieri* were sorted from the 520 specimens obtained in the study period, using a random-digits table. An abdominal ventro-sagittal incision was made from the anal aperture to the pelvic fin insertions, for removal of digestive tubes. The length of the digestive tube (distance between the beginning of the esophagus and the end of the rectum; DTL) was measured in order to establish the DTL/SL (digestive-tube length/standard length) ratio and to determine a possible relationship to the diet of *M. furnieri* (KNÖPPEL, 1970; UIEDA, 1995). The digestive tubes were then preserved in 70% ethanol until the analysis of diet contents.

The digestive tubes were divided into two portions, the first consisting of the pharynx, esophagus and stomach, and the second consisting of the intestine and rectum, due to the different degrees of digestion of the food in each portion. Finally, the contents of each digestive tube were identified to the lowest possible taxonomic level and quantified, when possible, as number of specimens. The volume of each item was measured according to the methods described by BEMVENUTE (1990) and PETTI et al. (1996).

Data analysis

The mean number of individuals (+SE) of *M. furnieri* was calculated for the study months and areas (southern and northern), and for the two areas combined. A histogram illustrating the relative frequency distribution of the size classes (standard length) was constructed for the total population sample.

The diet of *M. furnieri* was analyzed for the percentage composition (*PC*%), frequency of occurrence (*FO*%), percentage volume (*PV*%) and alimentary importance index (AI_i), separately for the stomach and intestine contents. Frequency of occurrence is the percentage of digestive tracts containing a particular food item in relation to the total number of digestive tracts containing food (ZAVALA-CAMIN, 1996; BRANCO & VERANI, 1997), providing an estimate of how often a given item is consumed.

$$FO_i\% = \frac{Fi_1}{Fi_1 + Fi_0} \cdot 100$$

where: Fi_1 is the number of digestive tracts in which item *i* was present and Fi_0 is the number of digestive tracts in which item *i* was not present.

The percentage volume of the contents of the digestive tract, which provides an estimate of the relative contribution of each food item in the diet of a species (ZAVALA-CAMIN, 1996), was calculated according to the equation:

$$PV_i\% = \frac{V_1}{V_t} \cdot 100$$

where: V_i is the volume of item *i* and V_t is the volume of all items present in the digestive tract.

The alimentary index was calculated based on the frequency of occurrence (FO_i%) and percentage volume (PV_i%) of each item (KAWAKAMI & VAZZOLER, 1980):

$$I\,A_i = \frac{FO_i\% \,.\, PV_i\%}{\Sigma^n_{i=1}\,(FO_i\% \,.\, PV_i\%)}$$

For a seasonal analysis of the frequency of occurrence, percentage composition and volume, and also of the alimentary importance index, both the stomach and intestine contents were used. The frequency of occurrence was compared among the seasons and for the total for the ten most frequent items (*FO*% > 10%). The percentage composition and percentage volume were also compared among seasons and for the total, for the six numerically most important items (*PC*% > 10% for any portion) and for the seven most voluminous items (*PV*% > 3% for any portion). A relationship between the frequency of occurrence and the percentage volume was employed for the seven most important items (AI_i% > 1%) in the stomach and the two most important items (AI_i% > 1%) in the intestine.

RESULTS

A total of 373 individuals of *M. furnieri* were obtained in the trawls. This species was most abundant in the southern area of Caraguatatuba Bay and during the spring of 2003 (Figure 2). A progressive increase in density from October to December was observed in the southern area, reaching a mean of 90 individuals. After this period the density in this area decreased to a mean of 10 individuals/month and remained low until the end of the study period. In the northern area, the density of *M. furnieri* remained low during the entire study period, never exceeding 20 inds/month. The highest density of *M. furnieri* in the northern area occurred in December 2003, but was still low compared to that of the southern area.

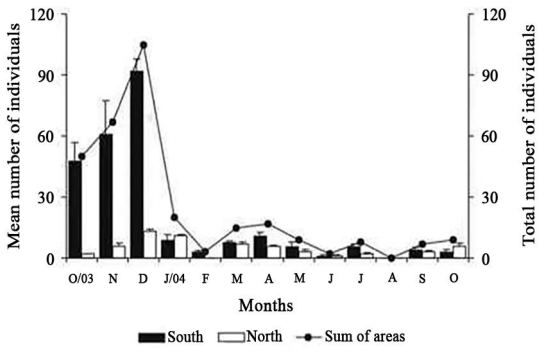

Figure 2. *Micropogonias furnieri*. Mean (+standard error) of the density of individuals in the two areas (southern and northern) in different months.

The individuals of *M. furnieri* were immature. The mean total length was 10.7 cm (ranging from 6.0 to 19.0 cm) and the mean standard length was 8.63 (ranging from 4.2 to 17.3 cm). The majority (93%) of the individuals were in the size classes between 5.0 and 12.0 cm, with a mode (41.5% of individuals) in the classes between 7.0 and 9.0 cm (Figure 3).

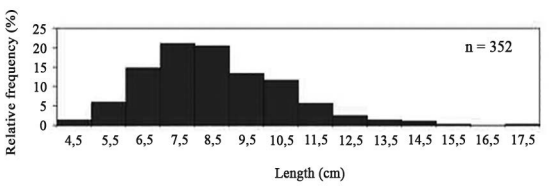

Figure 3. *Micropogonias furnieri*. Relative frequency (%) of individuals by size classes (standard length - cm) in the study period.

The diet of *M. furnieri* seems to be varied, since 19 items were found in the digestive tube (Table 1). All 19 items were found in the stomach contents, and 12 were found in the intestine. As the number of items found in the intestine was relatively high, both stomach and intestine items were included in the subsequent analysis. The digestive-tube length/standard length ratio was relatively low (DTL/SL = 0.338), which suggests a predatory habit (KNÖPPEL, 1970; UIEDA, 1995).

The most frequent items in the stomach were particulate organic matter, fragments of bivalve siphons, glycerid polychaetes, and crustacean fragments (Table 1). These last were also abundant in the stomach, followed by bivalve siphons and mysidaceans. The bulkiest item in the stomach was organic matter, followed by hermit crabs and crustacean fragments. Thus, the items with the highest alimentary importance indexes were organic matter, crustacean fragments, bivalve siphons, and glycerid polychaetes. Organic matter, shell fragments, shells of the bivalve *Pitar* sp., nematodes, and amphipod tubes were frequent in the intestine. Numerically, *Pitar* sp. shells, organic matter, amphipod tubes, and crustacean fragments were important in the diet, while with respect to volume, organic matter and shell fragments were the most important items. Organic matter had an alimentary importance index of almost 90% in the intestine. The second most important item (9%) was shell fragments.

Considering seasonal variations in the frequency of stomach contents (> 10%), organic matter was most frequent in summer, when it reached 100%; followed in descending order by winter, autumn, and spring (Figure 4). Bivalve siphons were most frequent in winter and least frequent in summer. Glycerids, amphipod tubes, crustacean fragments, and nematodes were most frequent in summer, while polychaete fragments, mysidaceans, and *Pitar* sp. were absent in this season. *Pitar* sp. was also absent in spring. Nematodes were absent in spring and winter. Shell fragments were scarce in autumn. In the intestine, organic matter was the most important item, reaching almost 100% in all seasons (Figure 4). The frequencies of shell fragments and *Pitar* sp. shells were highest during autumn, while nematodes were most frequent in winter.

The number of individuals found in the stomach of *M. furnieri* showed some seasonal variations (Figure 5). Bivalve siphons were consumed more in autumn than in other seasons. Mysidaceans, however, were more numerous in spring, organic matter in winter and summer, and amphipod tubes in

Table 1. *Micropogonias furnieri*. Frequency of occurrence (*FO*%), percent composition (*PC*%), percent volume (*PV*%) and alimentary importance indices (AI_i). Total number of individuals (N = 159), individuals with empty digestive tube (Ne = 2), mean standard length (SL = 9.47), digestive tube length and standard length ratio (DTL/SL = 0.34)

Food items	Stomach				Intestine			
	***FO* (%)**	***PC*%**	***PV* (%)**	**AI_i *100**	***FO* (%)**	***PC*%**	***PV* (%)**	**AI_i *100**
Phylum Cnidaria								
Gorgonian fragments	0.85	0.14	0.12	0.0026				
Phylum Nematoda								
Nematoda not identified	1.71	0.28	0.06	0.0026	13.73	5.73	0.21	0.0448
Phylum Sipuncula								
Sipuncula not identified	3.42	0.56	0.31	0.0263				
Phylum Echiura								
Echiura not identified	3.42	0.56	0.15	0.0128				
Phylum Mollusca								
Shell fragments	0.85	0.28	0.63	0.0134	22.22	5.56	26.92	9.2255
Class Gastropoda								
Olivella minuta	0.85	0.56	2.15	0.0460				
Class Bivalvia								
Bivalve siphon fragments	37.61	23.16	5.58	5.2586	1.31	0.33	0.04	0.0008
Pitar sp.	1.71	0.28	1.25	0.0537	19.61	38.95	2.66	0.8041
Phylum Annelida								
Class Polychaeta								
Polychaete tube fragments	0.85	0.14	0.15	0.0032	4.58	2.45	0.35	0.0244
Polychaete fragments	16.24	7.91	2.54	1.0322	4.58	1.64	0.42	0.0299
Gliceridae	25.64	6.21	4.93	3.1636	0.65	0.16	0.02	0.0002
Phylum Crustacea								
Crustacean fragments	20.51	23.31	17.50	8.9885	9.80	9.82	1.29	0.1957
Class Malacostraca								
Order Decapoda								
Hermit crab not identified	3.42	0.71	19.11	1.6361				
Order Mysidacea								
Mysidacea not identified	11.97	19.35	3.73	1.1185	0.65	0.16	0.05	0.0005
Order Amphipoda								
Amphipod tube fragments	7.69	2.97	0.45	0.0863	12.42	13.42	0.75	0.1427
Phylum Brachiopoda								
Brachiopoda not identified	0.85	0.14	0.03	0.0006				
Phylum Chordata								
Class Pisces								
Fish scales	0.85	0.71	0.06	0.0013	0.65	0.16	0.01	0.0001
Fish bones	0.85	0.14	0.03	0.0006				
Others								
Organic matter	76.07	12.57	41.24	78.5531	86.27	21.60	67.29	89.5315
Total		100	100	100		100	100	100

winter. Crustacean fragments, amphipod tubes, and organic matter followed the same seasonal pattern in both the stomach and intestine. Crustacean fragments occurred in higher numbers in the stomach, and the other items in the intestine (Figure 5). Bivalve siphons and mysidaceans, the dominant items in the stomach, were practically absent in the intestine.

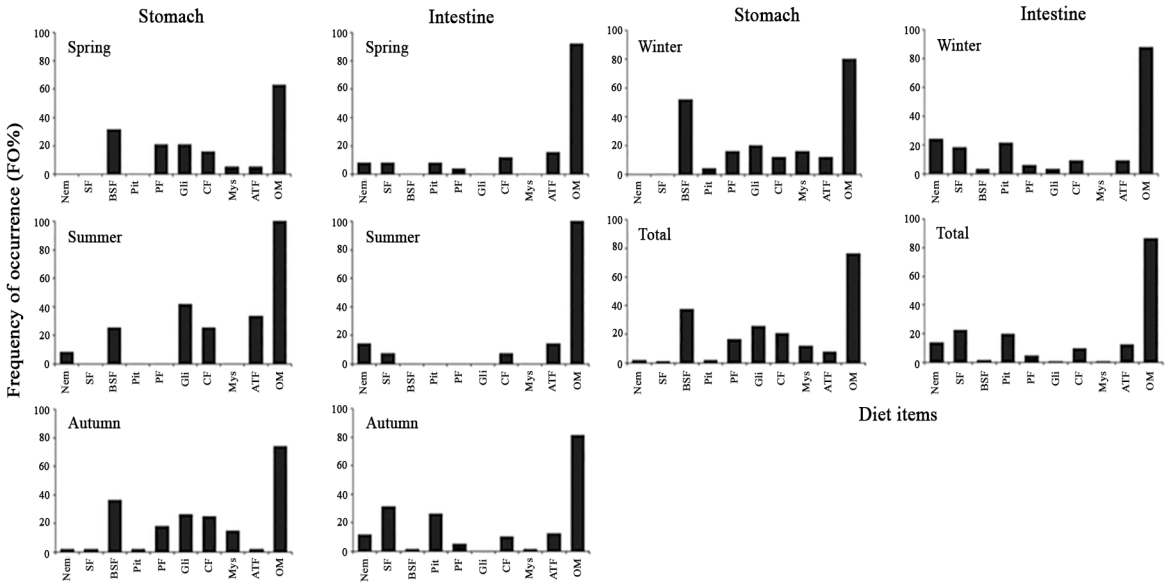

Figure 4. *Micropogonias furnieri*. Frequency of occurrence of the most frequent items (≥ 10%) in different seasons, and the total for any stomach or intestine portion. (Nem = Nematoda; SF = Shell fragments; BSF = Bivalve siphon fragments; Pit = Pitar sp.; PF = Polychaete fragments; Gli = Polychaete Gliceridae; CF = Crustacean fragments; Mys = Crustacean Mysidacea; ATF = Amphipod tube fragments; OM = Organic matter).

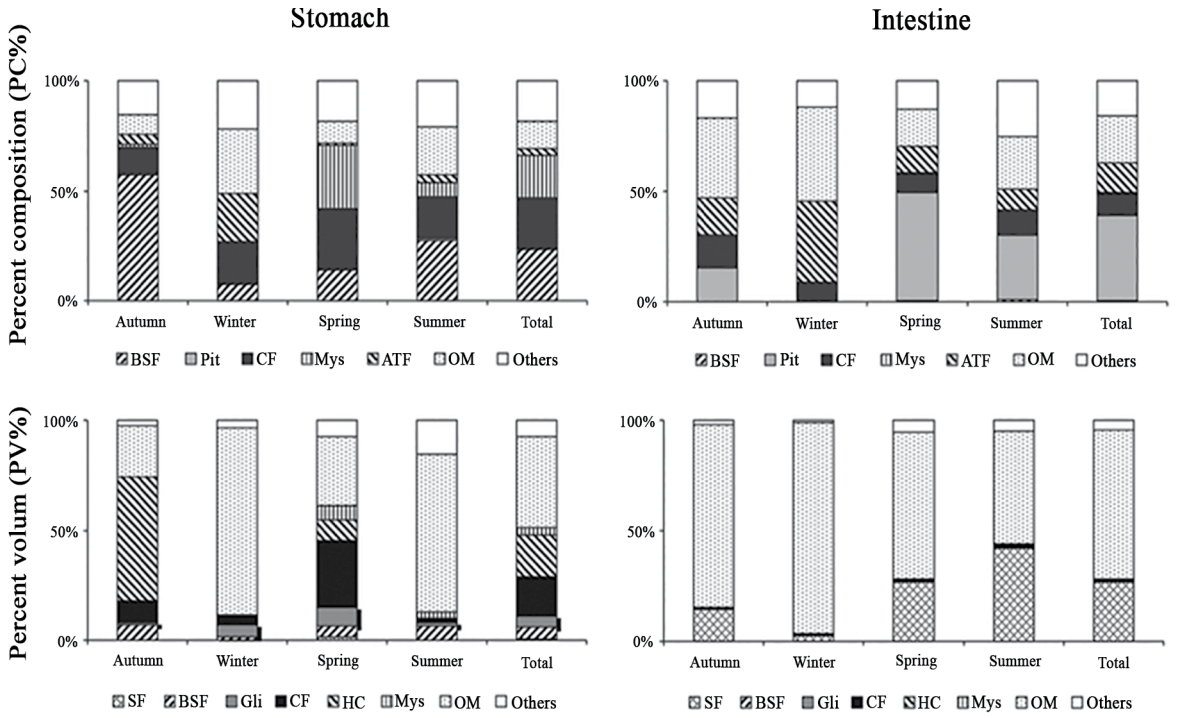

Figure 5. *Micropogonias furnieri*. Percentage composition and percentage volume of the most abundant (≥ 10%) and voluminous (≥ 3%) alimentary items in different seasons, and the total in any stomach or intestine portion. (SF = Shell fragments; BSF = Bivalve siphon fragments; Pit = Pitar sp.; Gli = Polichaete Gliceridae; CF = Crustacean fragments; HC = Hermit crab; Mys = Crustacean Mysidacea; ATF = Amphipod tube fragments; OM = Organic matter).

Pitar sp., however, was absent in the stomach, but was the most important item in the intestine in spring, and was absent in the intestine in winter.

In terms of volume in the stomach, the presence of hermit crabs was significant in autumn, with a decrease in the other seasons (Figure 5). Organic matter was the most voluminous item in winter and summer, while crustacean fragments were important in spring. In the intestine, the volume of shell fragments was small in autumn compared with organic matter (Figure 5). This difference increased considerably in winter, due to the decrease in the presence of shell fragments, but in spring and summer, the frequency of shell fragments increased, thus reducing the importance in volume of organic matter, which reached almost 50% in summer.

The alimentary importance index of the stomach portion (Figure 6) showed the high importance of organic matter, in both frequency and volume. Bivalve siphons were the second item in importance in terms

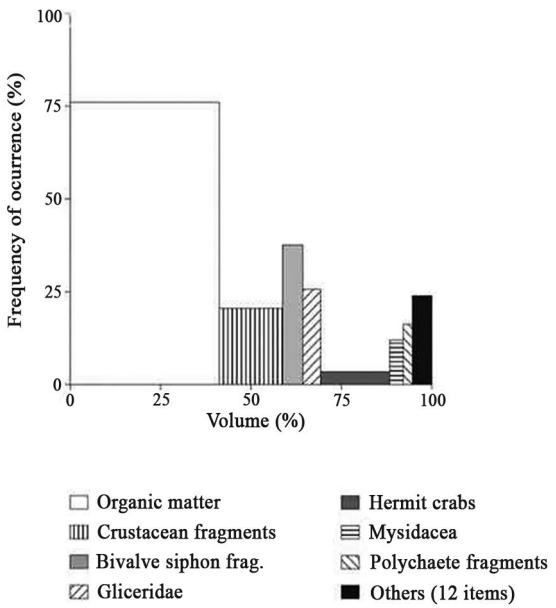

Figure 6. *Micropogonias furnieri*. Relationship between the frequency of occurrence and the percentage volume of the items with the highest alimentary importance indices ($AI_i \geq 1\%$) in the stomach portion.

of frequency of occurrence. Crustacean fragments and hermit crabs were important in terms of volume. In the intestine, organic matter had absolute importance (Figure 7).

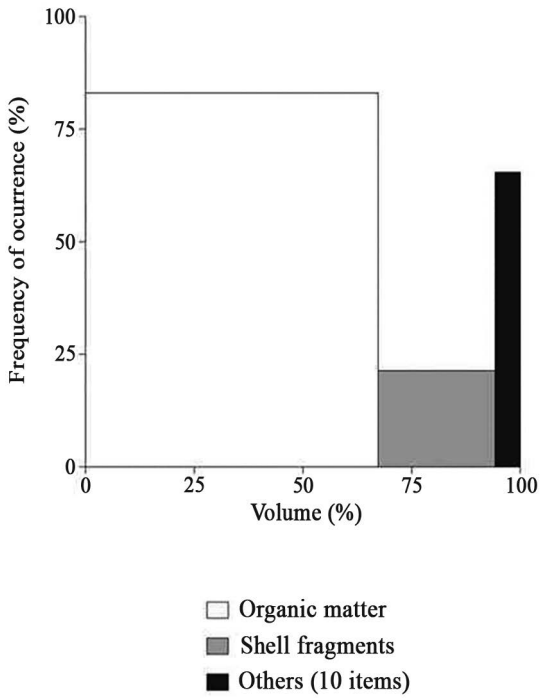

Figure 7. *Micropogonias furnieri*. Relationship between the frequency of occurrence and the percent volume of the items with the highest alimentary importance indices ($AI_i \geq 1\%$) in the intestine portion.

DISCUSSION

M. furnieri was restricted to the southern area of Caraguatatuba Bay, a region influenced by the Juqueriquerê River and the mangrove forest along its outlet. According to FIGUEIREDO & VIEIRA (1998), the ontogenetic spatial distribution of juveniles of this species is as follows: (1) up to 30 mm in total length, massive numbers of larvae and juveniles are present in the estuary; (2) from 20 to 30 mm, the juveniles change from the planktonic to demersal habitat, occupying the shoreline areas and shallow waters in the estuary, and remain there until they reach 180 mm; (3) after 90 mm, they may return to deeper areas, and (4) above 200 mm, they may remain in the estuary until they reach 300 mm, or migrate between the estuary and the coastal region, or definitively exit from the estuary, completing their development in the shallow coastal waters. As the individuals of *M. furnieri* obtained in Caraguatatuba did not exceed 200 mm in total length, this study agrees with the findings of FIGUEIREDO & VIEIRA (1998), who recorded juvenile individuals occupying an estuarine-like area.

Organic matter predominated in both the stomach and the intestine. High organic-matter contents have been reported for this species by other authors. FIGUEIREDO & VIEIRA (1998) observed that 44% of the fish had high proportions (50% to 70% of the total volume) of digested organic matter, reaching 100% in 19.4% of the cases.

The high content of particulate organic matter in the stomach contents may reflect continuous ingestion of food, rather than direct consumption of particulate organic matter. FIGUEIREDO & VIEIRA (2005) found that the stomach of the whitemouth croaker remain almost full during most of the day. These investigators suggested that ingestion is continuous, followed by rapid digestion. The relationship between the digestive-tube length and the standard length (DTL/SL ratio) showed that the species has a short intestine, corroborating the hypothesis of rapid digestion of animal matter in the stomach. In this study, a difference of 41.24 to 67.29% of the total volume was found between the stomach and intestine, respectively, which reflects the more-advanced stage of digestion of the food in the intestine. The literature on this species characterizes it as a generalist predator (see below), and many authors tended to eliminate the organic remains from the dietary analysis.

Another factor that may contribute to the high frequency and volume of organic matter is the accidental ingestion of deposited organic particles. The rivers entering Caraguatatuba Bay contribute large amounts of organic particles that are then deposited on the bottom. As this croaker proved to feed on both planktonic and benthic organisms, it may accidentally ingest large volumes of these particles.

In general, *M. furnieri* has a varied diet that includes polychaetes, mollusks, crustaceans, echinoderms (ophiuroids), and a wide range of fish species (VIEIRA et al. 1998, FRERET & ANDREATA, 2008; MENDOZA-CARRANZA & VIEIRA, 2008). Studies on *M. furnieri* agree in finding that younger individuals tend to eat more planktonic prey, while adults feed on benthic species. The larger individuals may also feed on other fish (SINQUE, 1977; PUIG, 1986; VAZZOLER, 1991; MENDOZA-CARRANZA & VIEIRA, 2008). These studies also report that polychaetes and crustaceans predominate in the diet of this species (TANJI, 1974; VAZZOLER, 1975; AMARAL & MIGOTTO, 1980; GASALLA, 1995; FIGUEIREDO & VIEIRA, 1998; FRERET & ANDREATA, 2008; MENDOZA-CARRANZA & VIEIRA 2008). *M. furnieri* feeds continuously and does not have a determined feeding period (SOARES et al., 1993; FIGUEIREDO & VIEIRA, 1998). Investigators have also tended to consider that this species shows a generalist-opportunist feeding behavior: generalist due to the large number of different items ingested, and opportunist because it rarely feeds on anything but the most numerous and/or voluminous prey items (FIGUEIREDO & VIEIRA, 1998).

The diet of *M. furnieri* in Caraguatatuba Bay is in accord with that recorded by other studies on this species in Latin America. Most fish were between 60 and 120 mm, *i.e.*, juveniles, as observed in the above-cited studies. These young fish fed mainly on polychaetes, bivalve siphons, and mysids, this last a planktonic group. Other planktonic items such as copepods, eggs, and larvae were not observed for the individuals from Caraguatatuba. In addition to mysids, the importance of crustaceans in the diet of *M. furnieri* in Caraguatatuba Bay was evidenced by the large number of undetermined fragments of this group, and by the large volume of hermit crabs in its diet. Similar opportunistic behavior was observed in Caraguatatuba Bay, with variation in the use of resources: the fish tended to ingest larger volumes of the most abundant items in each season. This generalist-opportunistic behavior is also evidenced by the species-specific composition of the diet of *M. furnieri*.

An unusual habit revealed for the diet of *M. furnieri* in Caraguatatuba Bay is its grazing on bivalve siphons. This may result from the high density of the bivalve *Tivela mactroides* in the area (DENADAI et al., 2005), although the siphons could not be identified to species level. According to SOARES et al. (1993), whitemouth croaker has taste buds in the mentonian barbels, which makes it possible for them to perceive low-motility prey such as bivalves. Feeding on *T. mactroides* siphons has been reported for sciaenid fishes in Venezuela (MCLACHLAN et al., 1996). FIGUEIREDO & VIEIRA (1998) observed this for *M. furnieri* in the Lagoa dos Patos estuary; they considered this a *sui generis* event and an extremely

opportunistic behavior, when the fish, remaining close to a bivalve bank, feed on the siphons exposed on the bottom.

Some indigestible items, such as the shell fragments, *Pitar* sp. shells, amphipod tube fragments, and crustacean fragments were found in high frequencies in the intestine of *M. furnieri*. It is possible that the organic parts of these items were digested in the stomach, with only the inorganic portion remaining in the intestine. The potential for these inorganic parts to accumulate in the intestine was not known previously. Nematodes were also highly frequent in the intestine, but cannot be considered an indigestible item. These organisms have a soft body wall, which is easily digestible, but are presumably endoparasites since no evidence of digestion was found. PEREIRA JR. et al. (2002) found five nematodes parasitizing the digestive tube of *M. furnieri*.

The results of this study demonstrated that the population of *Micropogonias furnieri* in Caraguatatuba Bay is dominated by juveniles, which occur in higher abundance in the southern area during October to December (spring). *Micropogonias furnieri* can be considered a carnivore with a preference for consuming benthic organisms such as crustaceans, bivalve siphons, and polychaetes.

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